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CO2 Emissions, Trade Openness and GDP Percapita : Bangladesh Perspective

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MA in Economics of International Trade and European Integration

Dissertation:

CO₂ Emissions, Trade Openness and GDP per capita:
Literature Review and Empirical Study on the Case of
Bangladesh

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Abstract

In recent decades, the relationship between international trade, environmental problems and growth remains controversial topics for the economic literature. This paper mainly deals with the interactions among these three key issues of Bangladesh economy. Johansen's co-integrating methods have been used to analyze the interaction. Estimation shows one co-integrating vector exists in the model. Findings suggest that the adjustment speed is faster for trade openness while CO₂ emissions and GDP per capita have slow adjustment speed of restoration towards the long-run equilibrium. Granger causality test indicates the apparent bidirectional causal link between trade openness and GDP per capita but no causal link has been found from trade openness to CO₂ emissions and from GDP per capita to CO₂ emissions in both short run and long-run. Except GDP per capita and trade there are other factors which cause these emissions, such as population, but they are not included in the present model. The overall estimation implies that the current situation needs to draw attention to lower the existing emissions without blaming the international trade relations for causing CO₂ emissions and focus more on the growth performance to increase the GDP per capita.

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Introduction

The earliest global concerns over the impact of trade and economic growth on the environmental degradation started to appear in the 1970's, when it became apparent, that human population, at that time only half the population of today, use more resources compared to what environment can reproduce. After the "golden 60's", decade of unprecedented economic boom and rapid expansion of world trade, the sudden increase of the resource prices and alarming environmental degradation led to the decision to incorporate some environmental regulations, in order to be achieved more sustainable development. The adoption of environmental policies, however, remains highly controversial till today with many opponents questioning the results of such policies. The main proponents in the discussion over the relationship between the trade and environment could be divided into two opposing groups.

The advocates of trade liberalization argue that environmental regulations serve as hidden trade barriers which are highly inefficient and potentially harmful for the economy and even the environment and only free trade can guarantee fair and sustainable economic growth and with it subsequent improvement of the environment. The main argument in favor of the free trade is the ambiguous relationship between higher income and improving environmental standards observed in some developed countries. As trade has been widely accepted among mainstream economists to be welfare improving, assumingly free trade will raise the income in the developing countries, where the environmental standards are low and with the improving living conditions the households will demand higher environmental standards and eventually the environment will improve.

On the contrary the critics of the trade liberalization believe further trade liberalization will have devastating and irrevocable impact on the environment and the natural resources. Perhaps in their favor is the argument that despite of the remarkable regenerative ability of the environment, there is a point from which there is no recovery, fact which can be easily attested by the long list of endangered and extinct species throughout the short period of the human industrial activity. Even if the tradeoff between higher income, improved living conditions and the environment is assumed it is practically impossible to calculate the actual value of the

economic loss of the reduction in the priceless biodiversity. The global ecosystem is a very fragile organism of biological interdependency which it still not fully understood by the science and even relatively small disruption can cause significant threat eventually even for us. Moreover, throughout the human history there are countless examples of extinct civilizations and empires because of irrational overexploitation of resources, most notoriously renowned the population of Easter Island, but as well perhaps ancient Egypt, Maya civilization or even the Roman Empire.

Abstracting from the bipolarizing debate, the economic literature studying the relationship between the trade and its impact on environment has provided so far ambiguous results and arguments supporting both sides.

The aims of this paper is to briefly sketch the literature review on the relationship between trade, growth and environment and to empirically investigate the interaction between CO₂ emissions, trade openness and GDP per capita in Bangladesh. More specifically, it examines whether the variables are related to each other and provided that they are related, what are the causal links in the short run and long-run in Bangladesh holding other economic factors constant.

The first part of this work briefly reviews the most influential theoretical and empirical studies untangling the relationship between the trade and the environment. This chapter is further divided in to three sub-sections each presenting more details on the subsequent topics: the impact of the environmental regulations on comparative advantages, specialization and patterns of trade, the “industry flight hypothesis” and the “Environmental Kuznets Curve”.

In the second part the reader has the chance to find out more details on the growth performance and international trade scenario of Bangladesh up to date as the empirical study is based on Bangladesh economy and the constitution of the Bangladesh CO₂ emissions according to origin by type of fuel and sectoral contribution.

The third part presents the source of data, methodology and the result discussions, the overall empirical model studying the relationship between CO₂ emissions, trade openness and GDP per capita for Bangladesh.

In the last part of the paper the concluding remark on the overall study are presented.

1. Literature Review¹

The early works related to the economic literature studying the relationship between the trade and the environment can be traced back to the beginning of the 1970's as a response to the collective decision of many industrial countries to address more responsibly the growing concerns over the environmental issues with economically simulative sanctions. Sadly the economic stagnation during the 1980's pushed back the importance of the environmental topics as many countries were trying to revive their economies, however the economic upraise and rapid expansion of trade during the 1990's and beginning of 21st century proved to be the most fruitful decades for the economic literature so far, providing wide range of theoretical and empirical studies regarding various trade and environmental topics. This could be explained by the great variety of different models, definitions of environmental externalities and methodology. In general the theoretical models support the hypothesis that environmental regulations could distort the comparative advantages and reduce the competitiveness of the polluting sectors in favor of countries who do not comply with the environmental regulations. At the same time many empirical studies find evidence that the shares of the pollution intensive industries have reduced in many industrialized countries in comparison to number of developing countries, which supports the hypothesis that pollution intensive industries are migrating from countries with high environmental standards due to high abatement costs towards usually developing countries where the environmental standards are much lower. Despite the enormous volume of the economic literature dedicated to the topic, however, there is no sufficient evidence that could link trade directly to the worsening of the global environment.

¹ Xing, Y., Kolstad, C., 1996, "Environment and Trade: A Review of Theory and Issues" and Anríquez G., 2002 "Trade and the Environment: An Economic Literature Survey" present more complete review of the economic literature on the topic.

1.1 Impact of the environmental regulation on comparative advantages, specialization and patterns of trade

Comparative advantage is defined by the international trade theory either according to the classical Ricardian theory by differences in technology or according to the neoclassical Heckscher-Ohlin theorem by differences in factor endowments as technology is assumed to be constant. In case of rise in the strictness of the country's environmental regulations, there will be increase in the abatement costs and reduction in the pollution disposal capacity of the environment. Consistent with both theoretical schools free trade will shift the comparative advantages in favor of the country with lower environmental strictness which will consequently specialize in the pollution intensive industry. Similar conclusions were reached in the theoretical works by Pethig (1976), Siebert (1974, 1977), McGuire (1982), Carraro and Siniscalco (1992), Copeland and Taylor (1994) and Leger (1995). These theoretical results however capture only standard gains from trade and omit the welfare gains from the improvement of the environment.

Additionally Sartzetakis and Constantatos (1994) analyze a two country model with identical level of strictness but with different environmental policies. Authors conclude that country with tradable pollution permits system is more optimal compared to centrally planned level of emissions.

Alternative method to model the environmental policy is when environment is viewed as a factor of production. In this case, optimal property rights are the most suitable environment policy in order to prevent the overexploitation of the environment. In general, developing countries suffer from widely spread corruption and the environmental property rights failure is common problem which is believed to be the cause of the rapid deterioration of the environment in those countries. In the simple North-South trade models such as Chichilinski (1994) the North is traditionally modeled as externality free while the South suffers from property rights failure. As a result openness to trade predestines the South to lose from trade while the North receives standard gains from trade. Brander and Taylor (1997) carry out a more elaborated North-South trade model defining environment as a renewable resource. The authors contradict Chichilinsky's result with the argument that both countries can benefit from the mutual trade, under the condition that the price of the environmental input is sufficiently high and the real comparative advantage shifts back to the North which starts to export the pollution intensive good.

Alternatively Karp, Sacheeti, and Zhao (2001) present a South-South model which yields multiple equilibriums contingent to whether the pattern of trade is inefficient when both trading partners lose or at least one has initial gains, or whether the patterns of trade are efficient, in which case both partners gain from free trade or at least one is indifferent.

1.2 Testing the “Industry Flight Hypothesis”

The above mentioned theoretical framework suggests that the country with stricter environmental standards assumingly an industrialized country will lose its comparative advantage to country with more lenient environment standards which in an open economy scenario with perfect mobility of capital will cause pollution intensive industries to shift to the country with lower abatement costs. This theoretical proposition is referred to as the “industry flight hypothesis” or “pollution haven hypothesis” in case the environmental policy of the country is intended to attract foreign capital inflows. The consequences of such a “dirty industry migration” could have profound economic impact on the country with stricter environmental regulations resulting in increased unemployment and contracting revenues. The significance of such consequences raises serious political concerns. The debate over the validity of the “industry flight hypothesis” has generated large amount of empirical work with contradicting results.

Early studies on the impact of the stricter environmental policy on the pollution intensive industries throughout 1970’s such as US Department of Commerce (1975), OECD (1978) and Ugelow (1982) found no significant impact on the comparative advantages and patterns of trade. However, later works by Leonard and Duerksen (1980), Walter (1982) and especially Robinson (1988) provide evidence supporting the “industry flight hypothesis”. Walter (1980) shows that oversees subsidiaries of selected US transnational corporations have lower pollution abatement costs, while Robinson (1988) presents evidence of increase in the share of the pollution content in US imports compared to export for the period from 1973 till 1982. In contrast, econometric analysis conducted by Bartik (1988), McConnel and Schwab (1990) and Toby (1990) reject the validity of the hypothesis.

Throughout 1980’s the phenomenon of relocation of “dirty” industries became more widely accepted, however, Lucas, Wheeler, and Hettige's (1992) present evidence suggesting it was not due to international trade as the share of polluting industries grew faster in closed

developing countries compared to developing open market economies. Low and Yeates (1992) provide similar findings. Grossman and Krueger (1992) estimate the environmental impact of NAFTA on Mexico-US trade and reject the significance of the impact of the lower environmental regulations in Mexico on migration of the US pollution intensive industries, moreover, their computed general equilibrium model predicts that Mexico will specialize in cleaner industries, as a result of its abundant low cost labor, while capital abundant US and Canada will expand their pollution intensive industries.

Mani and Wheeler (1999) provide substantial evidence of the “polluting industry flight” hypothesis over the time period of 1960 till 1995; however, they admit there are more factors besides stricter environmental standards affecting the relocation of the dirty industries from industrialized countries towards developing economics. Furthermore, Wheeler (2001) based on data from the developing countries which received largest share of world’s foreign direct investment (FDI): Brazil, Mexico and China, shows reduction in the urban air pollution suggesting environmental improvement in favor of the international trade. In addition, Eskeland and Harrison (2002) examine FDI flows from US to Mexico and Venezuela and from France to Morocco and Côte d’Ivoire and reject the explanation of these flows by lower environmental costs.

Levinson and Taylor (2001), and Ederington and Minier (2001) use pioneering analysis of the impact of US the environmental regulations on trade flows by estimating the environmental policy as endogenous variable, unlike the previous studies which treat it as an exogenous variable. Based on data of US imports from Canada and Mexico for the period 1974 till 1986, Levinson and Taylor (2001) provide evidence that when environmental costs are defined as endogenous variable, environmental policy unambiguously affects trade flows. Similarly Ederington and Minier (2001) examine cross section data of the US manufacturing industries imports for the period of 1978 till 1992 and find significant evidence of a negative relationship between environmental regulations and imports, which suggests that the environmental policy could be used as a powerful mechanism to protect import competing sectors.

Analogously, environmental policy could be used in favor of strategic exporters by improving country’s international competitiveness with lower environmental standards. This alarming prediction raises concerns about future hypothetical scenarios such as “environmental

dumping” and “race to the bottom”. In the first case, a country voluntarily sets more lenient environmental policy in order to capture unfair international market advantages, in the second case developing countries are dragged into vicious “environmental wars” in order to attract more foreign investment they are forced to continuously lower environmental regulations.

1.3 Links between Trade, Development and Environment –The Environmental Kuznets Curve

It is not easy to examine the impact of trade on the environment as apparently there is no direct linkage and in order to be able to study it, it is necessary to disentangle this complex relationship. Perhaps the most influential work on the subject in question has been carried out by Grossman and Krueger (1993), who decompose the influence of trade on the environment into scale, composition and technique effects.

The scale effect is referred to the change in the emitted pollution as a result of the change in the total output of the economy holding the sectoral composition and technology constant.

The composition effect refers to the change in the sectoral structure of the economy after opening to trade as a result of comparative advantages, specialization and subsequent factor reallocation.

The technique effect refers to the change in the technology as a consequence of influx of foreign capital after opening to trade.

In order to estimate the final impact of trade on the environment it necessary to examine the consequences of each individual effect on the economy. If the economy has specialized in pollution intensive industries, the expansion of the output as a result of opening to trade will cause environmental degradation through the scale effect. In addition, after opening to trade if the country still enjoys comparative advantage in the pollution intensive industries the environmental quality will further decrease as the pollution sectors will expand at the expense of the cleaner industries which will contract, on the other hand, if the country loses its comparative advantage in the pollution intensive industries, the composition effect could improve the environmental quality as the country could specialize in cleaner industries. The technique effect is considered to be always environmentally improving as regardless of the impact of the previous

two effects the influx of more efficient technology will reduce the pollution emissions. The environmental quality will be determined by the resulting impact of the dominant effect.

The most widely accepted channel of interaction between trade openness and environment is through income per-capita., as a result of the extensive consensus of the positive impact of trade and foreign direct investment on growth. Therefore, further research has been dedicated on the impact of growth on environment.

Grossman and Krueger (1993) carry out cross-country analysis of relationship between sulfur dioxide (SO₂) and dark matter emissions and income. They find evidence that the emissions and income follow an inverted U-curve similar to the relationship observed by Simon Kuznets between growth and income inequality, which is why this curve was named Environmental Kuznets Curve (EKC). The important feature of the curve is that it captures the change in the environmental quality as income rises. Intuitively, in the first stage pollution rises alongside with the income until certain threshold level of income when the demand for higher environmental quality rises and pollution decreases.

This highly influential work has inspired large amount of empirical studies examining the validity of the relationship for different countries and wide range of pollution measures, however, there seems not to be a decisive consensus. It is accepted the EKC does hold for certain pollutants, especially with local and direct harmful effects like NO₂, SO₂ and CO, while the validity for pollutants with long-run global effects like CO₂ and other greenhouse gases is unconfirmed.

2. Bangladesh – Growth, Trade and CO₂ Emissions²

2.1 Overall Growth and Trade Performance

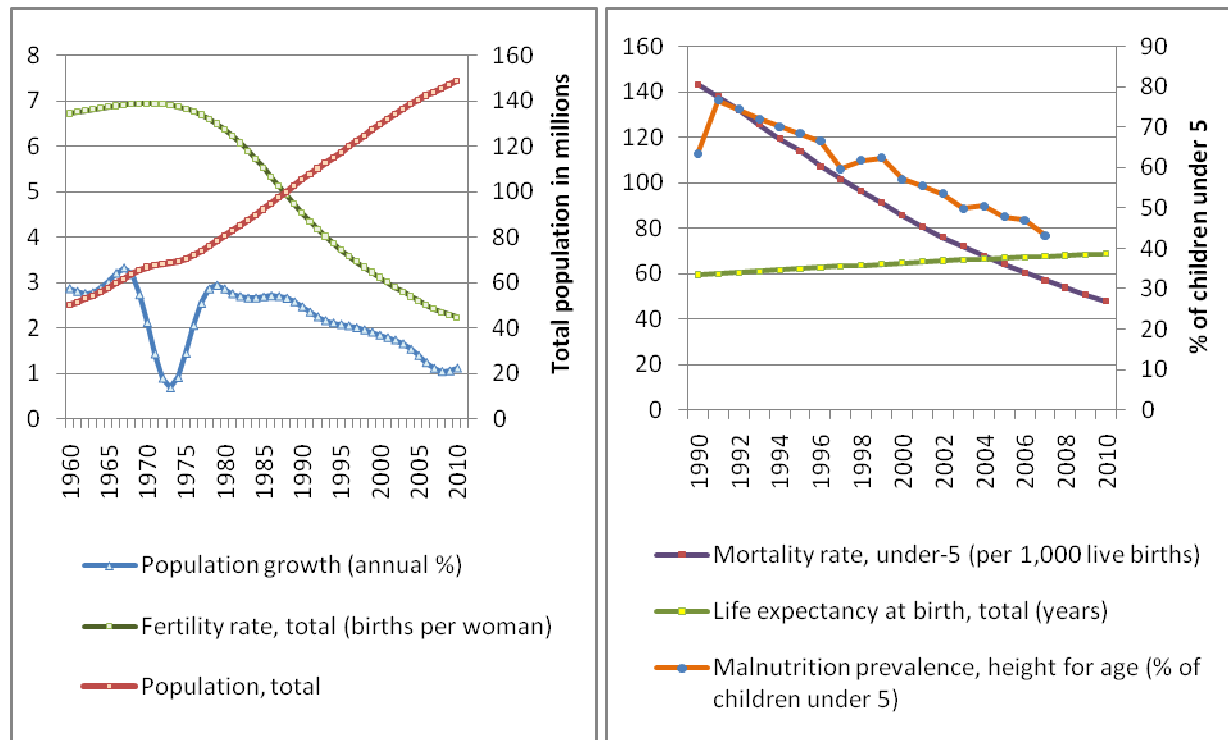
People's Republic of Bangladesh is the official name of the small country situated in the fertile delta of the Ganges-Brahmaputra river system, locked in a land borderline between Burma and India from the east to the west and to the south strategically opening to the Bay of Bengal. Since its independence from Pakistan in 1971 this young nation has went through tremendous demographic, politic and socio-economic changes. Although starting as one of the most impoverished countries, thanks to the economic liberalization, which took place in the beginning of the 1990's, nowadays Bangladesh is one of the fastest growing developing countries, appointed by Goldman Sachs investment bank as one of the Next Eleven countries believed to become leading economic powers alongside the BRIC countries in throughout pace of the 21st century. Despite its fast growing economy, Bangladesh is facing serious socio-demographic and climatic challenges, which slow down the pace of country's economic growth and if not addressed adequately they may jeopardize country's future development.

One of the main obstacles for Bangladesh's future development are country's overpopulation and the wide spread chronicle poverty. Since its independence Bangladesh population has nearly doubled from 70 million to nearly 150 million nowadays, this makes it the eighth most populous nation in the world and with the area of 147.6 thousand km² the ninth most densely populated country in the world, at the same time with nearly 60% of the population younger than 25 one of the youngest nations. Since the introduction of the contraception in the 1980s, however, the annual population growth has reduced from nearly 3% to slightly above 1% and the fertility rate has considerably fallen down from 6 to 2 average births per women. One of the most impressive achievements of Bangladesh, however, is the substantial reduction in its dependency on foreign aid, in the recent years, in order to feed its enormous population. Despite its territorial limitation and the low productivity of agriculture, famines seem to be problem of

² All data collected from World Development Indicators (World Bank, 2010), Bangladesh Bank, Bangladesh Bureau of Statistics, Export Promotion Bureau, Petrobangla

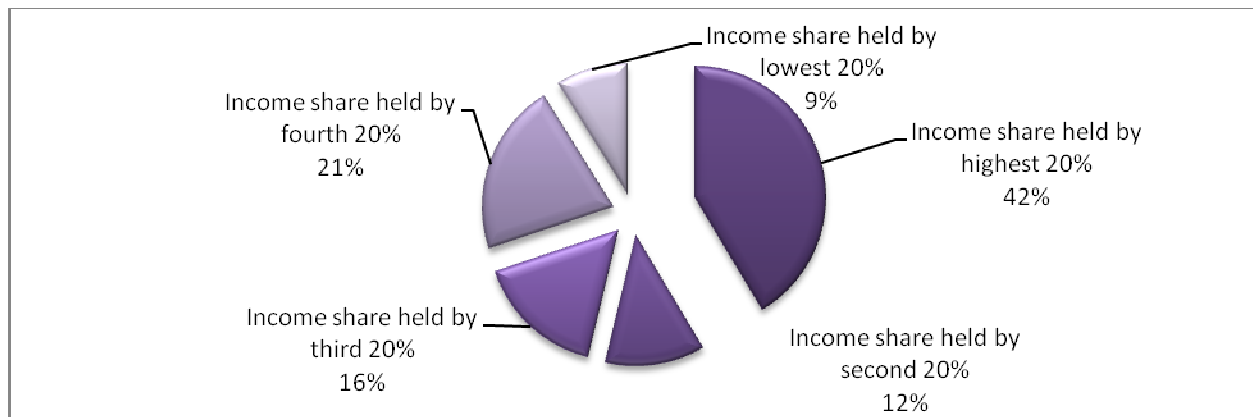
the past, with the exception of occasional localized occurrence. On the other hand, malnutrition remains one of the most profound challenges for the Bangladesh leaders. Especially the malnutrition amongst children under age of 5 reaches up to 40%, which is one of the highest in the world.

Figure 1: Left Diagram - Bangladesh population growth, fertility rate and total population for the period 1960 – 2010; Right Diagram mortality rate and malnutrition of children under 5, and life expectancy for 1990 – 2010 (Source: World Bank 2010)



Despite the rapid economic development the poverty level remains significantly high, however, the poverty headcount ratio has falling down dramatically from 56.6% in 1992, at the beginning of the economic liberalization, to 31.51% in 2010. On the other hand, the gap between rich and poor has been alarmingly growing; the GINI index rose from 27.6 in 1992 to 32.12 in 2010, and while the income share held by the top 10% rose from 23.2% in 1992 to 27.03% in 2010, the income share of the bottom 10% declined from 4.13% in 1992 to 3.99%.

Figure 2: Bangladesh income distribution in 2010 (Source: World Bank 2010)



As it was mentioned earlier, the rapid economic growth of Bangladesh was fuelled up by the substantial economic liberalization at the beginning of the 1990's. Nonetheless, at the beginning, immediately after the liberalization, the Bangladesh economy took the opposite direction towards protectionism and economic isolation. The newly formed socialistic government, which took control of the impoverished by the devastating war country, was suddenly facing running out of foreign exchange reserves, as a consequence of the dramatically worsening balance-of-payment caused by rising import and deteriorating export prices. Traditionally Bangladesh economic engine was powered up by the production of jute, which attributed by up to 70% of the export earnings in the beginning of 1970's, nevertheless, cheaper polypropylene products rapidly took over the jute worldwide and the jute industry quickly declined. As a result, highly prohibitive barriers to trade were installed, which practically cut off Bangladesh from the global economy and an instant wave of nationalization followed bringing basically the entire manufacturing and services sectors of economy under direct control of the government. The average annual growth of GDP during the years of country's restoration from the Liberation war for the period 1971 – 1980 reached barely 1.04%. Throughout the 1980's some modest deregulation measures were introduced, which stimulated denationalization of some public enterprises and the emergence of Bangladesh future economic powerhouse; the ready-made garments industry. During the period of the initial economic recovery in the 1980's the average GDP growth speeded up to 3.73%. Since the democratic changes in 1991 the gradual political liberalization was followed by further economic deregulations, which accounted for substantial tariff and nontariff reduction, flexible exchange regime of the Bangladesh Taka and export promoting incentives. Trade openness ratio increased from 19% in 1991 to nearly 49% in 2008. Export to GDP ratio increased from 7% to 20% for the same period, as well as the import

to GDP ratio grew from 12% to nearly 29%. The economic liberalization in the 1990's accelerated the average GDP growth to 4.8% and during the first decade of the 21st century the Bangladesh grew on average with 5.8%. Despite the tight financial and monetary discipline followed by Bangladesh, in order to keep the consumer prices stable, the inflation is fluctuating around annual level of 8% since 2005, which has negative impact on the investment and slows down the growth.

Figure 3 Tariff rate reduction and increase of trade openness for the period 1991 – 2010 (Source World Bank 2010)

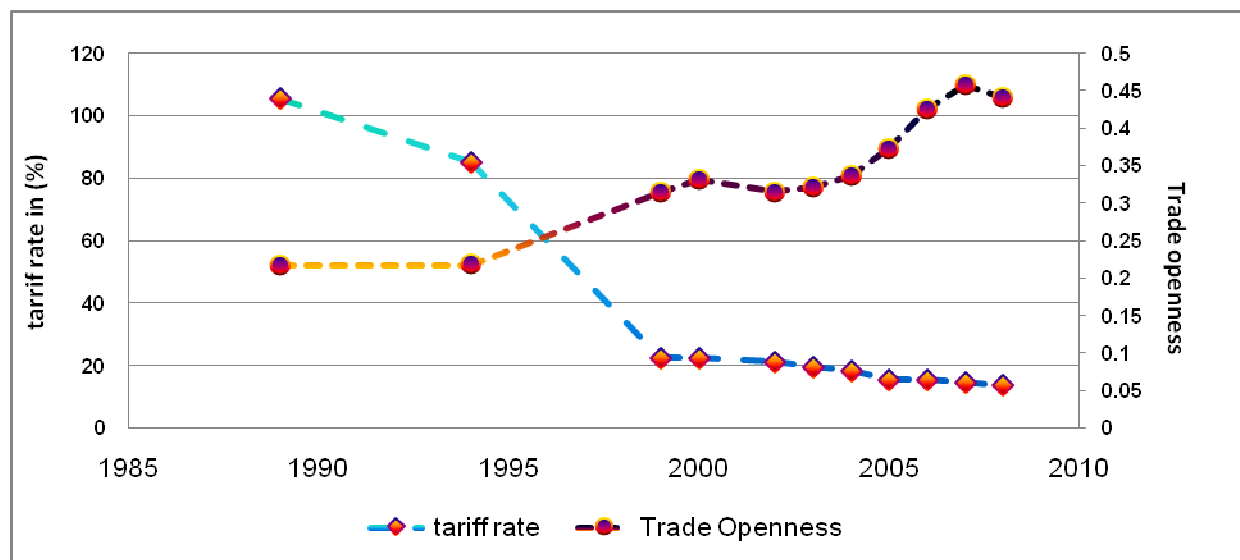
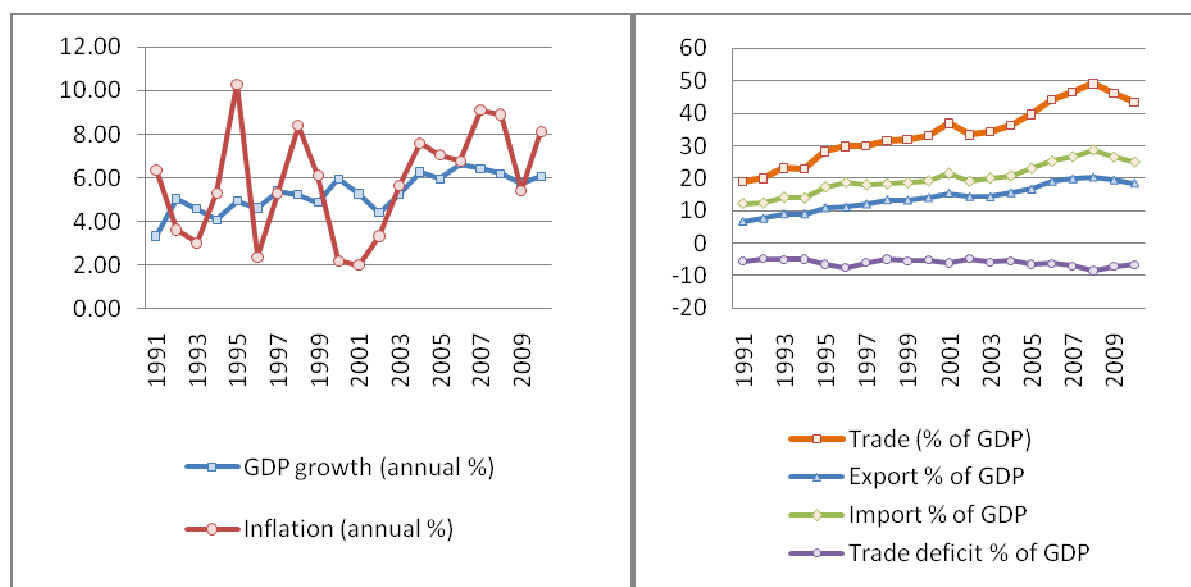


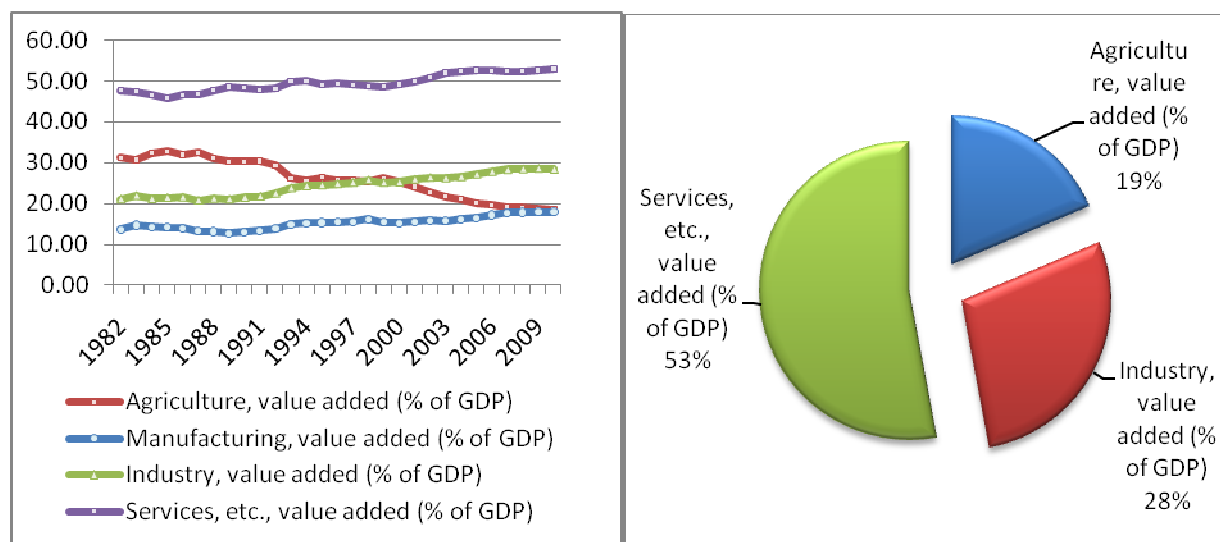
Figure 4 Bangladesh GDP growth, inflation and trade to GDP ratios for the period 1991 to 2009 (Source: World Bank 2010)



Besides the impressive economic growth of the Bengali economy the basic economic composition has gone through some substantial changes as well. At the beginning of the

economic liberalization in 1980's consumption accounted for slightly above 90% of the GDP and throughout 1990's it has dropped to around 82% nowadays. While the value added in agriculture corresponded to 31.55% of GDP in 1980, this share has reduced to 18.59% in 2010. On the other hand the value added share of the industry rose from 20.63% of GDP in 1980 to 28.46% in 2010, mainly as a result of the rapid expansion of the ready-made garments sector. The manufacturing alone accounted for 17.89% of the value added to GDP ratio. The share of the value added by the service sector, however, remained relatively constant with modest increase from 47.81% of GDP in 1980 to 52.96% in 2010. Despite the radical decrease in the value added, the agriculture remains the main source of employment with around 48% of all employed, substantial decline compared to 66.4% in 1991. Agriculture is main source of income mainly for the poorest Bangladesh people and the majority nearly 70% employed are women. Industry employs about 15% of the total employees and although the share of the females employed in this sector is around 13% of total employed, 90% of them work in the ready-made garment sector, which is another important source of income for the poorest portion of the population. Alarming, at least 80% of female employment accounts for low value added sectors, which raises serious concerns about gender pay gap. In contrast, highest value added sector, the services employs in majority men with above 40% compared to modestly 20% women of all employed.

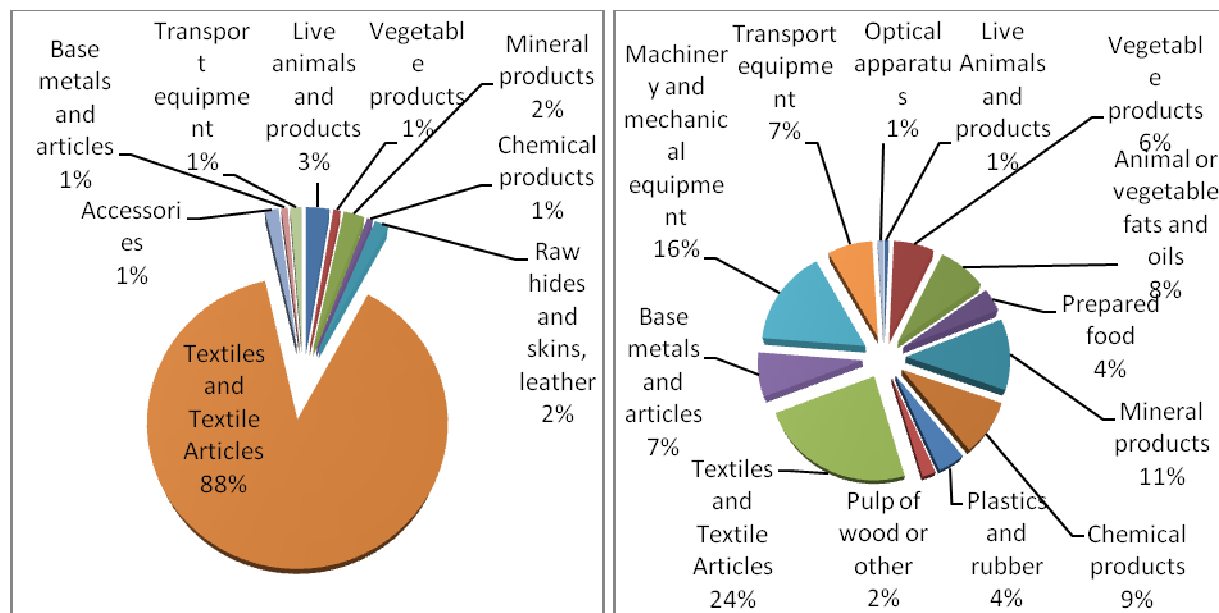
Figure 5: Left Diagram - Dynamic expression of sectoral value added to GDP for the period 1982 till 2009; Right Diagram – Sectoral value added as % of GDP in 2010 (Source: World Bank 2010)



As mentioned earlier economic liberalization had tremendous stimulating effect on the Bangladesh economy through the rapid expansion of the ready-made garment industry, the fuel

that currently speeds up Bangladesh economic engine. Bangladesh specialization in the sector is product of the progressive trade liberalization on national and global level, Bangladesh gargantuan supply of cheap labor and the favorable international climate in the sector. In 2010 textiles and textile articles constituted above 80% of total Bangladesh exports, majority of which above 80% of all merchandise exports are destined to high-income economies. As one of the least developed countries, Bangladesh enjoys preferential tariff and quota access to the European Union single market, as a result European Union countries from the biggest market share exceeding 53% of Bangladesh total textile exports. Additionally, NAFTA countries represent another 23% share of Bangladesh exports, despite the losses from the higher tariff rates and the intense competition from other East-Asian countries, which Bangladesh textile industry has to face. On the other hand, Bangladesh mainly imports from developed and fast developing countries of South and East Asia. Chinese imports constitute more than 17% of total imports in 2010, while imports from neighboring India amount to nearly 14% of the total imports, in addition, imports from South-East Asian countries sum up to approximately 15%, while imports from EU 27 group and Japan add to around 7% and 5% respectively. Main import articles are intermediary imports related to the ready-made garment industry, such as textile fabrics and yarn (18% of total imports) and machinery equipment (16% of total imports), furthermore, food imports remain significant (14% of total imports), as well as petroleum products derivatives (18% of total imports). As a result of chronicle excess of imports over exports, Bangladesh suffers long-run trade deficit fluctuating around the 5% share of GDP, which has negative impact on the balance of payment and the foreign reserves, in spite of that; the current account balance ends up in surplus since 2006, as a result of the enormous amount of remittances (nearly 11% of GDP in 2010) sent home by workers from abroad, which is crucial for financing the growing trade deficit and serves as inflow of fresh foreign reserves, making up for the low foreign direct investment (only around 1% of GDP).

Figure 6: Structural composition of Exports (Left Diagram) and Imports (Right Diagram) (Source: World Bank 2010)

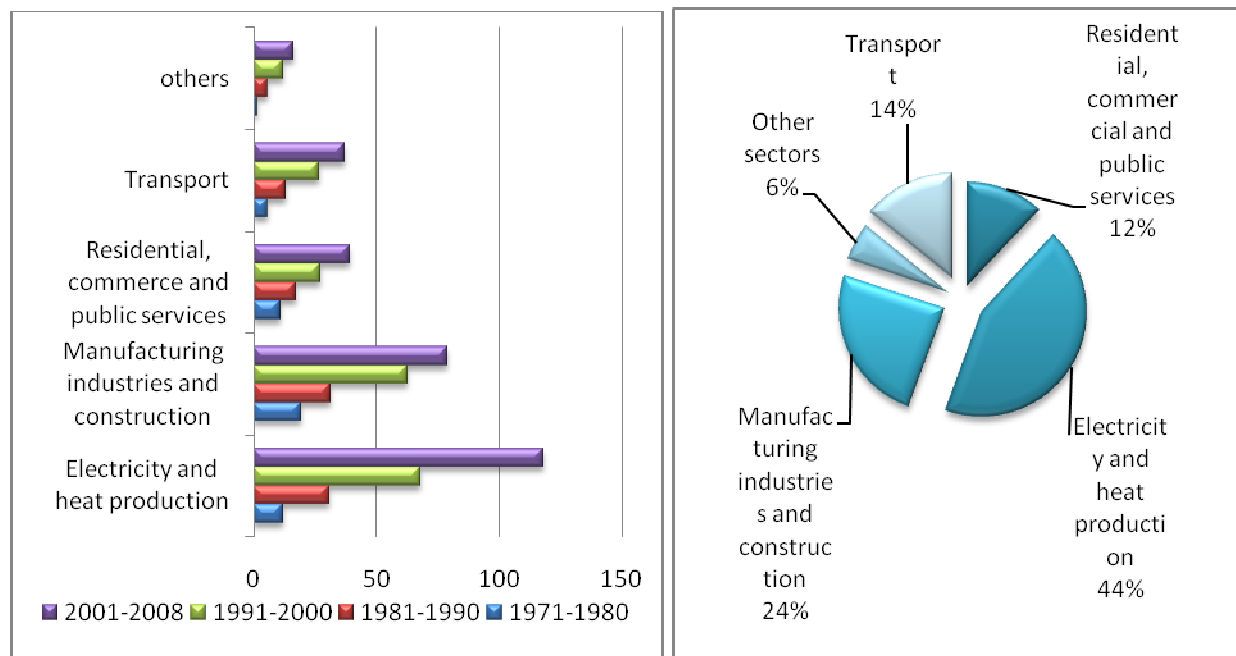


Despite the distinctive achievements in development, Bangladesh progress remains contradictory. Although, population growth and fertility rate have been reduced substantially, visible positive effects are expected to take off in not so near future and the enormous population remains a setback for Bangladesh speed of development. Even though, Bangladesh does not face occurrence of large scale famines any more, malnutrition remains profound problem, particularly alarming is the share of children suffering from undernourishment. The rapid expansion of Bangladesh middle class and economic boom is seen by many as one of the brightest perspective of Bangladesh future; on the other hand, the gap between population with higher income and people living in poverty is increasing, although the poverty headcount is steadily reducing. Despite the relatively high economic growth throughout the last decade, the speed of growth remains below 7% target, necessary to effectively bring down the poverty and to achieve sustainable economic development. Regardless of the tremendous success in the ready-made garment industry, such a narrow economic specialization brings along potential instability, as the economy is more vulnerable to exposure of foreign demand shocks similar to the recent global financial and economic crisis, which can have devastating consequences for the economy as a whole and large portion of the population, foreign reserves and country's liquidity and could cripple the essential future growth.

2.2 Bangladesh CO₂ Emissions³

Bangladesh produces annually approximately 50 megatons CO₂, which is for a country with such an enormous population moderate pollution. In global comparison it is comparable to what 7 million Bulgaria produces, a small East-European post-communistic country, despite the fact that Bangladesh population is more than 20 times bigger and Bangladesh economy is nearly twice as big as the Bulgarian. Intuitively it could be implied that Bangladesh economy is oriented towards relatively low CO₂ emissions, as a result of its massive comparative advantage in cheap low skill labor, which tends to be demanded by less pollution intensive industries. Specifically speaking, the engine power of the current Bangladesh economy is the ready-made garment sector, a considerably low CO₂ emitting industry⁴. What is alarming, however, is the fact that just for one decade Bangladesh emissions have almost doubled, as a consequence of the rapid expansion of Bangladesh middle class demanding more electric power and transportation fuels, unlike Bulgarian emissions, which have reduced to nearly half the amount since the fall of the communistic regime and remained nearly constant for the last decade. Therefore, Bangladesh emissions are expected to grow further in the near future, which is raising serious concerns about its sustainable development.

Figure 7: Sectoral composition of Bangladesh CO₂ emissions by decades in millions of metric tons (Left) and shares of total in 2008 (Right), (Source: World Bank 2010)

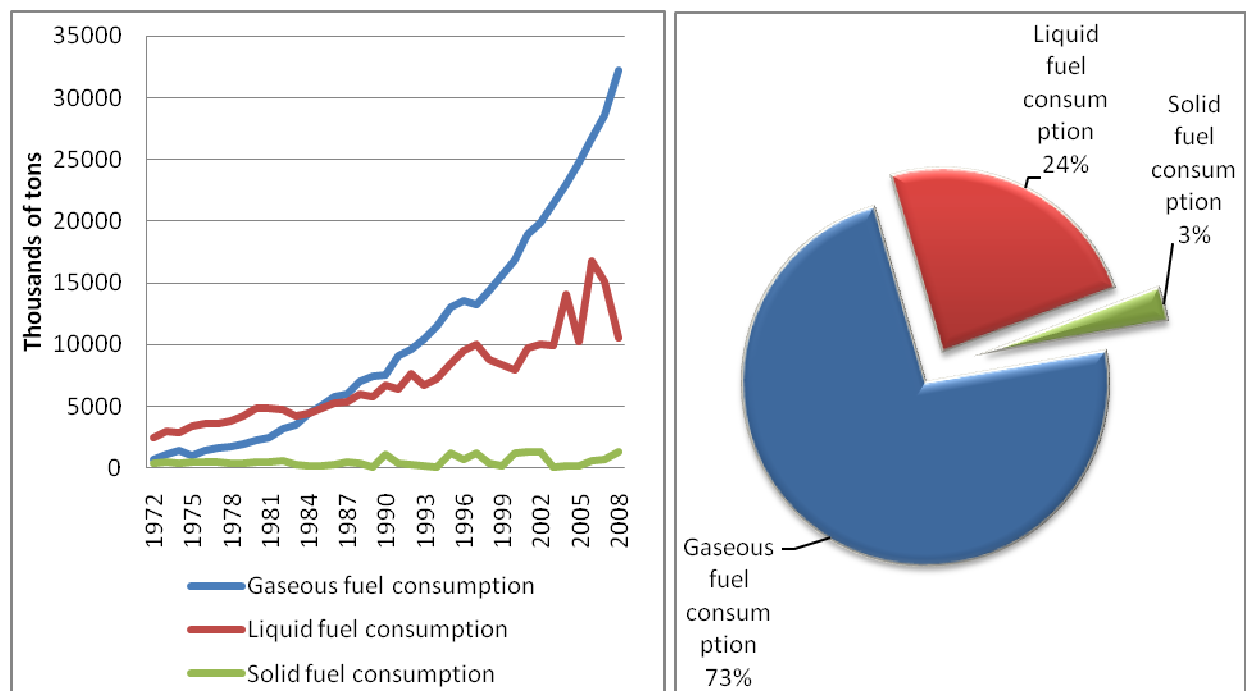


³ World Development Indicators (World Bank, 2010)

⁴ Although, nearly 80% of all Bangladesh water pollution in 2008 was caused by the textile industry.

The argument that Bangladesh CO₂ emissions are driven by the domestic consumption is based on the fact that almost 45% of all CO₂ emissions are by-product of the electricity and heat production, another 12% of the emissions are related to residential buildings, commercial and public services and transport related emissions amount to approximately 14%. Emissions from industrial activity accounted for most of the CO₂ emissions with above 40% share until the second half of 1980's, since then, however, its share has gradually reduced to 30%, despite the fact that in absolute quantity the CO₂ emissions related to the manufacturing sector remained almost constant around the amount of 10 million metric tons per year throughout the first decade of the 21st century. On the other hand emissions related to electricity and heat production and residential buildings, commercial and public services combined together nearly doubled from around 12 million metric tons at the beginning of the decade to more than 25 million in 2008. Total CO₂ emissions from transportation doubled as well from 3 million metric tons to above 6 million in 2008.

Figure 8: Bangladesh CO₂ emissions by fuel consumptions over the period 1972 – 2008 (Left) and by shares of total in 2008, (Source: World Bank, 2010)



The biggest share of Bangladesh CO₂ emissions is coming from gaseous fuel consumption, which accounts to more than 70% of the total, as a result of modest domestic reserves of natural gas, which can, however, hardly satisfy the growing domestic demand. Although the origins of geophysical and geological exploration on the territory of modern

Bangladesh can be traced back to the beginning of the 20th century, only small portion of the territory has been explored until today and more potential reserves are expected to be discovered in future exploration, especially in the territorial shelf of the Bay of Bengal. Until June 2010 approximately 21 trillion cubic feet of recoverable natural gas has been discovered, nevertheless, 8.5 of which has been already extracted, subsequently the net remaining reserves are estimated at about 12.5 trillion cubic feet. With average daily production of approximately 2 billion cubic feet these reserves are estimated to last for about 20 years, the production, however, does not meet the demand resulting in shortage of approximately 500 million cubic feet per day, which has to be additionally imported. Power generation constitutes around 60% of total gas consumption, from which 17% is produced in captive power plants. In addition, electricity generated by natural gas formed nearly 92% of the total thermal generation in 2010. Furthermore, household consumption amounts to approximately 12% of the total consumption, while the industry as a whole and the fertilizer production alone use each 9% of the total gas consumption. Rising petrol prices result as well in increasing demand for compressed natural gas as a cheaper substitute for motor-vehicle fuel, which constitutes around 6% of the total gas consumption.

Besides the increasing demand for electric power, the rapidly growing middle class results in rising number of private cars and mounting consumption of petrol and its derivatives. The emissions from liquid fuel consumption are estimated to correspond to above 25%, significant reduction compared to above 60% share in 1980's, as a result of Bangladesh reorientation towards cheaper gas consumption. The share of the electricity generated from diesel and furnace oil thermal power stations corresponded to less than 5%.

The CO₂ emissions from solid fuel consumption are estimated at the share of below 2% of total emissions. Generated electricity from coal amounted to less than 3% of total thermal power in 2010, in addition total coal imports have reduced by nearly 99% since the beginning of the decade, as a result of Bangladesh deepening dependence on gas consumption. Remaining emissions are related to conventional burning of coal and wood for heating purposes by the poorest population.

3. The Empirical Study

Figure 9: Bangladesh GDP per capita, trade openness and CO₂ emissions over the period of 1972 – 2008 (World Bank, 2010)

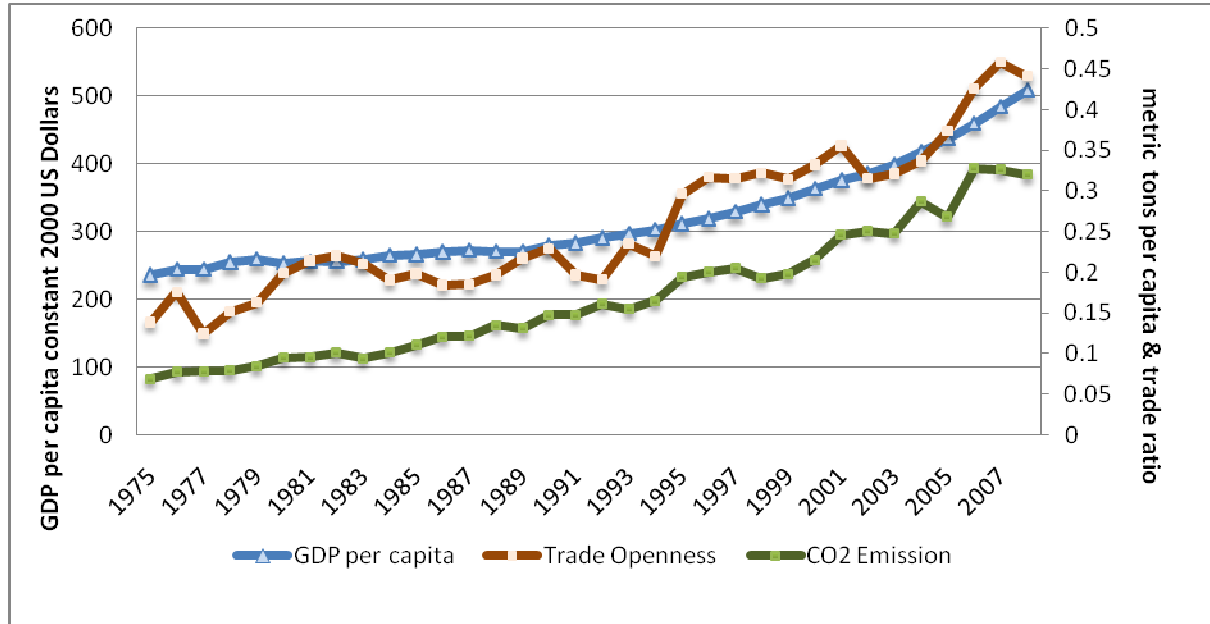


Figure 9 presents the real scenario of Bangladesh GDP per capita, CO₂ emissions and trade openness for the last four decades. For the last two decades Bangladesh is enjoying gains from participating in the international trade as a result of trade liberalization in the 1990's and growing GDP per capita is evidence of these gains. At the same time, CO₂ emissions are also increasing, which raises environmental concerns about future sustainable development of Bangladesh. The three upward moving series for the selected time period indicate long-run relationship among them, however, based solely on this observation it cannot be implied whether rising CO₂ emissions in Bangladesh result directly from trade openness, rising GDP per capita, or rather from other factors. The empirical estimation has been carried out in order to disentangle the relationship among these series.

3.1 Data

This research paper examines time series data of Bangladesh CO₂ emissions per capita, GDP per capita and trade openness. The secondary data used in this paper have been obtained from World Development Indicators (Word Bank, 2010). CO₂ emissions per capita are expressed in metric tons, GDP per capita is measured at constant prices of 2000 in thousands of dollars and the trade openness ratio has been calculated in the general method (Export + Import)/GDP , where exports and imports are measured at constant prices of 2000 in thousands of dollars as well. The time period used for the estimation is from 1975 to 2008. The series are transformed in logarithms after first difference. All computations are done using Stata 11.2 software. The variables are expressed in the following forms; PCO₂ = CO₂ emissions per capita, PGDP = GDP per capita and OPEN = trade openness.

3.2 Methodology

The methodological approach used in this paper includes three steps: unit root test, co-integration test and causality check.

In the first step, the univariate properties of the variables have been examined, as in general, time –series data exhibit non-stationary properties which can lead to spurious regression. For this purpose unit root test has been performed, the Augmented Dickey-Fuller test (ADF) (1979 and 1981). The regression for ADF test is given in the following:

$$\Delta Y_t = \mu + \beta t + \gamma_1 Y_{t-1} + \sum_{i=1}^p \theta_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

Where Y is the variable being investigated, Δ denotes the first difference, t is the time trend and p is the lag. If the null hypothesis $\gamma=0$ cannot be rejected, then the investigated variable has a unit root, hence, the time series is non-stationary.

In order to investigate the co-integration relationships, Johansen technique has been used. Engle and Granger (1987) linked the co-integration with the error correcting model but the vector auto-regression framework was developed by Soren Johansen (1988, 1991). The methods

in the Stata software are based on the maximum likelihood (ML). This method gives the scope to select independent choices for endogenous variables and at the same time it allows to estimate both the long-run and the short-run adjustment information.

In order to analyze the multivariate system, a var-model with p lags was considered in the following form:

$$Y_t = \Phi D_t + \Pi_1 Y_{t-1} + \dots + \Pi_p Y_{t-p} + \varepsilon_t \quad (2a)$$

This var-model can be transformed to vector error correction model (VECM)

$$\Delta Y_t = \Phi D_t + \Pi Y_{t-1} + \Gamma \Delta Y_{t-1} + \dots + \Gamma_{p-1} \Delta Y_{t-p+1} + \varepsilon_t \quad (2b)$$

Here Y_t is a $k \times 1$ vector of endogenous variables; D_t is a vector of deterministic variables (intercepts trend...); Φ is a matrix of parameters associated with D_t , Γ_i contains the parameters that captures short-run impact, where $\Gamma_i = \sum_{j=i+1}^p \Pi_j$, $k \times k$ matrix ($i = 1, \dots, p-1$), Π $k \times k$ matrix contains the parameters that capture long-run impact and ε_t is the vector of disturbance term niid $(0, \Sigma)$.

If the series Y_t is $I(1)$, then the matrix Π has rank $0 \leq r \leq k$, where r is the number of linearly independent vectors (Engle and Granger (1987). Here Y_t will be co-integrated if the following rank condition $0 < r < k$ is satisfied, so $\Pi = \alpha\beta'$ as Π has reduced rank $0 < r < k$, where α and β both are $k \times r$ matrices of rank r . Both intercept and trend, which are estimated in this VAR model, have unrestricted coefficients. The estimated model also includes two lags⁵.

Before proceeding towards the reduced rank modeling, multivariate autocorrelation tests have been applied by performing the Prais-Winsten⁶ regression based on Durbin-Watson⁷ test⁸. In order to avoid the model misspecification, normality test has been executed as well.

⁵ Optimal lag number has been chosen based on Akaike's Information Criterion and Hannan-Quinn Criterion.

⁶ Prais and Winston (1954)

⁷ Durbin and Watson (1950), (1951), (1971)

⁸ Before correction DW test showed $d=0.7$ and after $d=2.33$.

In the final step the direction of the link of causality has been performed through Granger non causality test, (Granger Engle and Granger (1987)). In this paper the estimated VECM models are given in the following form:

$$\Delta \text{LPCO}_2_t = \Phi_1 + \alpha_1 \text{ECT}_{t-1} + \sum_{i=1}^k \lambda_{1i} \Delta \text{LPCO}_2_{t-i} + \sum_{i=1}^k \gamma_{1i} \Delta \text{LOPEN}_{t-i} + \sum_{i=1}^k \delta_{1i} \Delta \text{LPGDP}_{t-i} + \epsilon_{1t} \quad (3)$$

$$\Delta \text{LOPEN}_t = \Phi_2 + \alpha_2 \text{ECT}_{t-1} + \sum_{i=1}^k \lambda_{2i} \Delta \text{LPCO}_2_{t-i} + \sum_{i=1}^k \gamma_{2i} \Delta \text{LOPEN}_{t-i} + \sum_{i=1}^k \delta_{2i} \Delta \text{LPGDP}_{t-i} + \epsilon_{2t} \quad (4)$$

$$\Delta \text{LPGDP}_t = \Phi_3 + \alpha_3 \text{ECT}_{t-1} + \sum_{i=1}^k \lambda_{3i} \Delta \text{LPCO}_2_{t-i} + \sum_{i=1}^k \gamma_{3i} \Delta \text{LOPEN}_{t-i} + \sum_{i=1}^k \delta_{3i} \Delta \text{LPGDP}_{t-i} + \epsilon_{3t} \quad (5)$$

Where ECT_{t-1} is the lagged Error Correction Term derived from long-run co-integrating relationship, ϵ_{it} is serially uncorrelated random error terms with $(0, \Sigma)$. LPCO2, LOPEN LPGDP are the logarithmic expression of the variables PCO₂, OPEN and PGDP respectively. Δ is the first difference.

Equation 3 shows the causal link from trade openness and GDP per capita to CO₂ emissions; equation 4 shows the causal link from CO₂ emission and GDP per capita to trade openness and the last one shows causality running from trade openness and CO₂ emissions to GDP per capita. There are two ways to examine the causation, either through the statistical significance of the coefficient of lagged ECT (α 's) or through the lagged dynamic terms (λ 's, γ 's, δ 's), denoted by the significance level of the t- test and χ^2 test, respectively. The coefficient of the lagged error-correction term denotes the speed of adjustment leading towards the long-run equilibrium of the variable under investigation in each short-run period (e.g. per year).

3.3 Results and Discussion

Before proceeding towards the co-integration test to investigate the long-run relationship observed in Figure 9, unit root test has been performed in order to inspect whether all the series are integrated by the same order. The ADF test results from Table 1 show that, the time series for CO₂ emission and GDP per capita are non-stationary in the level form⁹ and stationary at the first difference¹⁰, only trade openness in the level form is stationary with trend but non-stationary without trend. At first difference all the variables are stationary I(0) with and without trend.

⁹ We do not reject the null H_0 : There is a unit root in the series

¹⁰ We reject the null in 9

These results suggest that all the series are integrated of order one $I(1)$, which indicates the possibility of the presence of co-integration among the series. Phillips-Perron test¹¹ also confirms these results.

Table 1: Augmented Dickey Fuller (ADF) Test¹²

	Level form		First difference	
	Constant with trend	No trend	Constant with trend	No trend
CO₂ emission	-2.1	0.5	-9.3	-9.4
Trade openness	-7.2	-1.3	-5.6	-5.7
GDP per capita	3.0	6.6	-7.6	-5.7

Table 2 shows the results of the likelihood ratio test for the number of co-integrating vectors. Both the eigenvalue and the trace test indicate that the null hypothesis of at most one co-integrating equation cannot be rejected; subsequently the present model of three series with two lags has one co-integrating vector, which indicates that there is long-run relationship among the CO₂ emissions, trade openness and GDP per capita in Bangladesh.

Table 2 Johansen Tests for Co-integration

Null Hypothesis	Eigen value	Trace Statistics	Critical value at 5% level
None	.	30.7	29.7
At most 1	0.4	12.8	15.4
At most 2	0.3	0.1	3.8

* Unrestricted co-integration rank test

The estimated parameters are presented in Box 1. Co-integrating vector is shown in normalized form as vector applies Johansen's normalization by default. All the signs are expected associated with the parameters of the long-run equilibrium relationships.

In general co-integration is associated with economic theories which imply long-run equilibrium relationship between time series. It can be said that co-integration is best explained when the series are $I(1)$. The intuition behind this is that the long-run equilibrium relationship cannot move too far from the equilibrium level because of the other economic factors that force

¹¹ See Appendix

¹² For the critical values see Appendix

restoration of the equilibrium relationship; therefore this disequilibrium state is not permanent. The presence of one co-integrating vector in this trivariate model confirms that there are two common stochastic trends which reveal that this is a short term phenomena for Bangladesh economy due to some structural changes, improper policy adoption or some short-run shock.

Box 1: Normalized co-integration relations and coefficients

$$\hat{\alpha} = \begin{pmatrix} -0.128 \\ (0.098) \\ 0.778^* \\ (0.138) \\ -0.102^* \\ (0.168) \end{pmatrix} \quad \text{and} \quad \hat{\beta}' = \begin{pmatrix} 1 & -0.778^* & 6.082^* \\ . & (0.161) & (1.509) \end{pmatrix} \quad \begin{pmatrix} \text{LPOC2}^{13} \\ \text{LOPEN}^{14} \\ \text{LPGDP}^{15} \end{pmatrix}$$

$$\hat{\Gamma} = \begin{pmatrix} -0.59^* & 0.02 & -0.06 \\ (0.133) & (0.08) & (0.539) \\ -0.22 & -0.23^* & -4.44^* \\ (0.186) & (0.113) & (0.756) \\ 0.03 & -0.03^* & -0.4^{*16} \\ (0.022) & (0.013) & (0.092) \end{pmatrix}$$

Estimated Trend Coefficient = -0.007
Estimated Intercept Coefficient = -0.003

The estimated coefficient of error correction term (ECT) $\hat{\alpha}_1$ has negative sign, which suggests stability in the system, as in the short run CO₂ emissions will converge towards the long-run equilibrium with speed of adjustment by 12.8% in one year, in other words it will take more than 8 years to restore the long run equilibrium. However, the coefficient is statistically insignificant, which denotes that in the long-run the endogenous variables do not cause each other. The estimated ECT coefficient $\hat{\alpha}_2$ is statistically significant at 1% level therefore in the long-run the series are causing each other and it has positive sign, which suggests that there is

¹³ Log of PCO₂

¹⁴ Log of Open

¹⁵ Log of PGDP

¹⁶ * denotes rejection of null hypothesis at the 5% level of statistical significance. Figures in bracket are the Std.Err

instability in the system and trade openness will diverge from the equilibrium as a result of previous disruption in the system. However absolute value of the coefficient denotes high speed of adjustment of 77% in one year. Within two years it can correct the long-run equilibrium. The ECT coefficient α_3 is also statistically significant at 1% level which also indicates all the variables are causing each other in the long-run and carries negative sign which suggests stable system. However if some disturbance occurs GDP per capita will converge towards the long-run equilibrium with the speed of adjustment 10% in one year. It will also take more than 8 years to return to the long-run equilibrium.¹⁷

In the final step short run causality links are examined through Granger Causality Wald Test. Estimated results presented in Table 3 provide non-causality direction from trade openness to CO₂ emissions and from GDP per capita to CO₂ emissions.¹⁸ Which also support the long-run causal links between these variables based on the insignificant coefficient of ECT α_1 . Intuitively these results could be interpreted by the fact that the economic engine that powers Bangladesh growth of GDP and exports is the ready-made garment industry which generates relatively low emissions of CO₂ in the short-run. On the other hand as Bangladesh imports CO₂ intensive products such as machinery equipment, petroleum products and derivatives, from other fast developing economies such as China, India and other South-East Asian countries, which emit large amount of CO₂ through domestic industrial production as a result Bangladesh industrial sector emits relatively less CO₂ emissions. In contrast, Bangladesh CO₂ emissions directly related to industrial activity amounts to only 24% share on total emissions¹⁹, while the biggest share, nearly 70%²⁰ of total CO₂ emissions, is result of electricity and heat production, transportation, residential buildings and commercial services, which are related to the enormous size of Bangladesh population. Moreover, despite the fast growth of Bangladesh economy in the last decade, this growth remains below 7% annual increase which is necessary in order to create significant impact on the GDP per capita, therefore it can be stated that in the short run GDP per capita is not in the sufficient level which can cause the CO₂ per capita emissions.

However, the marginality of the insignificance level in the long-run suggests that if there is a change in the composition of international trade and structural change in GDP per capita the causality linkages may occur. As the findings suggest that neither trade openness nor GDP per

¹⁷ This paper hasn't interpreted normalized co-integrating relation as long-run elasticities.

¹⁸ Null hypothesis for Granger causality test, (H_0 : all $\gamma_{1t} = 0$) openness does not Granger cause CO₂ emission and (H_0 : all $\delta_{1t} = 0$) GDP per capita does not Granger cause CO₂ emission, estimation do not reject the null.

¹⁹ Figure 7 (Right)

²⁰ Figure 7 (Right)

capita cause CO₂ emission in the both short run and long-run it can be assumed that there are other factors which are not included in the model. Such factors explaining these emissions could be for example population as mentioned earlier Bangladesh is an overpopulated country and this population creates CO₂ emissions in terms of energy consumption.

Table 3: Granger Causality Wald test

Null Hypothesis	Chi² statistics	Probability
LOPEN does not Granger Cause LPCO₂	3.33	0.54
LPGDP does not Granger Cause LPCO₂	4.14	0.66
LPCO₂ does not Granger Cause LOPEN	1.21	0.18
LPGDP does not Granger Cause LOPEN	15.18	0.00
LPCO₂ does not Granger Cause LPGDP	0.81	0.12
LOPEN does not Granger Cause LPGDP	15.96	0.00

For the direction from the CO₂ emission Granger non-causality test suggests that it does not cause GDP per capita and trade openness in the short run. However, significance of the ECT coefficients α_2 and α_3 suggest that GDP per capita and trade openness are caused by the CO₂ emissions in the long run. Figure 7 shows the increasing demand for electric power in Bangladesh, which results in growing CO₂ emissions. The notion behind this is as more people get access to the electricity, it is a sign of progressive development of the country and gradual rise in GDP per capita. Furthermore, as GDP per capita is rising as a consequence of the development process, the demand for diversified foreign products will also increase, which will have impact on the trade. Despite the model failed to provide evidence for causal linkages running from trade openness and GDP per capita in the short run and long-run, there seems to be unidirectional causality from CO₂ emissions towards trade openness and GDP per capita in the long-run. This suggests the variables are not neutral to each other in the long-run.

The most expected finding is that there is highly significant bidirectional causality both in the short-run and the long-run between trade openness and GDP per capita²¹. Intuitively, this result could be explained by the important role of exports on Bangladesh growth, in return growth influences not only the demand for foreign imports, but also the productive capacity of the economy and subsequently the exports. In addition, there is sufficient empirical evidence in support of this finding.

²¹ See Box 1 and Table 3

4. Conclusion

The economic literature presented in the first chapter failed to provide conclusive results on the impact of international trade on the environmental degradation, on the other hand there is a wide consensus among the authors that the environmental policy can distort the comparative advantages and change patterns of trade among countries. The theoretical framework implies that countries with lower environmental regulations, in general assuming developing countries, will specialize in the polluting intensive industries. However, if this specialization is due to only apparent comparative advantage under the illusion of lower environmental standards and not real comparative advantage, the country will lose from trade, while the externality free country will always gain.

Although the initial empirical research on the “dirty industry flight” hypothesis, widely predicted by the theoretical framework, failed to provide ambiguous results, later studies found more decisive evidence in support of the phenomenon. Furthermore, the higher “dirty” industry concentration could be observed in rather closed developing economies than in developing economies involved more intensively in the international trade, which implies more probable linkage of the “dirty industry migration” with the process of development rather than with international trade. In addition, more recent studies treating environmental policy as endogenous variable indicate the significant impact of the environmental regulations on the trade flows and how environmental policy can be use in order to protect strategic importing industries. This disturbing implication raises concerns about hypothetic scenarios such as “environmental dumping” and “race to the bottom”, which predict gradual environmental degradation with global consequences.

Large body of empirical research in the last decade has been dedicated as well on testing the validity of the hypothetical “Environmental Kuznets Curve”, which defines controversial relationship between the income and the environment. If proved this relationship could help explain the indirect impact of international on environment through income, however, up to date the evidence is mixed. While some pollutants, especially with local and direct harmful effects such as NO₂, SO₂ and CO emissions, seems to follow the EKC curve, for others, with predominantly global effects such as the greenhouse gases, this relationship hasn’t been proved.

The second part presented some evidence on Bangladesh achievements in its development; its sustainable development performance, however, remains contradictory, with main setbacks seen in overpopulation, growing gap between rich and poor and too narrow economic specialization in the ready-made garment industry. In spite of that, Bangladesh remains oriented towards relatively clean and low emission industry, as a result of its advantage in cheap labor, which produces considerably less pollution intensive goods. This could be observed from the relatively small share of CO₂ emissions generated by the manufacturing sector, in contrast majority of the CO₂ emissions are related to Bangladesh enormous population. In addition, Bangladesh energy sector almost entirely depends on natural gas, which produces significantly less CO₂ emissions compared to other fuels.

The findings ultimately indicate that there is some environmental degradation in Bangladesh. The results suggest that international trade, GDP per capita and CO₂ emissions, are related in the long-run, however, the Granger non-causality check failed to provide sufficient evidence for causal relationship in the direction from trade openness to CO₂ emissions and from GDP per capita towards CO₂ emissions in the both short run and long-run. Apart from the two variables, there are other factors causing CO₂ emissions in Bangladesh, which are not included in the model. Population is one of the main suspects. Insufficient environmental policies and regulations could be also responsible to large extent for the pollution in Bangladesh.

The total Bangladesh CO₂ emissions amounts to approximately 0.15%²² of the world's total CO₂ emissions, which is considerably low figure for country with such an enormous population. The reason behind this is the large portion of population which still doesn't have access to the electricity. However, with the development of the country the demand for electric power is growing day by day²³, based on which it is expected that CO₂ emissions will also gradually expand in the future. This hypothetical scenario raises some serious concerns about Bangladesh future development, as still large portion of the population earn their living in the agricultural sector and directly depend on the environment. As poor rural population is mostly exposed to climate change, rapid environmental degradation will have devastating implications for Bangladesh economy as a whole and could halt Bangladesh development. In order to pursue sustainable development Bangladesh policy makers will have to adopt balanced strategy in order to stimulate growth and international trade without sacrificing the environment.

²² World Development Indicators (World Bank, 2010)

²³ Figure 7

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Appendix

Table 4 Phillips Perron Unit Root Test²⁴

	Level form		First difference	
	Constant with trend	No trend	Constant with trend	No trend
CO2 emission (t test)	-1.8	1.4	-12.1	-12.4
(rho test)	-6.8	1.0	-40.8	-40.7
Traeopenness(t test)	-6.3	-1.9	-6.3	-6.1
(rho test)	-20.3	-7.3	-23.3	-24.5
GDP percapita	4.8	9.1	-7.8	-5.9
(rho test)	4.4	3.3	-43.4	-43.7

	Critical Values		
	1%	5%	10%
With Trend (t test)*	-4.2	-3.5	-3.2
(rho test)	-23.9	-18.73	-16.1
No Trend (t test)*	-3.6	-2.9	-2.6
(rho test)	-17.9	-12.8	-10.2

*denotes the critical value is applicable for ADF test also

²⁴ Phillips-Perron test (1987, 1988)